Executive Summary: Guidelines for the Prevention of Infections Associated With Combat-Related Injuries: 2011 Update

Endorsed by the Infectious Diseases Society of America and the Surgical Infection Society

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Abstract: Despite advances in resuscitation and surgical management of combat wounds, infection remains a concerning and potentially preventable complication of combat-related injuries. Interventions currently used to prevent these infections have not been either clearly defined or subjected to rigorous clinical trials. Current infection prevention measures and wound management practices are derived from retrospective review of wartime experiences, from civilian trauma data, and from in vitro and animal data. This update to the guidelines published in 2008 incorporates evidence that has become available since 2007. These guidelines focus on care provided within hours to days of injury, chiefly within the combat zone, to those combat-injured patients with open wounds or burns. New in this update are a consolidation of antimicrobial agent recommendations to a backbone of high-dose cefazolin with or without metronidazole for most postinjury indications and recommendations for redosing of antimicrobial agents, for use of negative pressure wound therapy, and for oxygen supplementation in flight.

Key Words: Guidelines, Infection, Combat, Trauma, Prevention.

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EXECUTIVE SUMMARY

Infectious complications of combat trauma have plagued man throughout the ages. Advances in body armor and in the medical care provided from the point of injury to definitive

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14. ABSTRACT

Despite advances in resuscitation and surgical management of combat wounds, infection r~mains a conceming and potentially prcvenr.able complication of combat-related injuries. Interventions currently u~ed to prevent these infect ions have not been either clearly defin<Xl or subjected to rigorous clinical trials. Current infection prevention mcasure.s and wound management practices are deriwd from rdrospcclive review of wartime experiences, from civilian trauma data. and Ji?om in Vitro and animal data. This update to the guidelines published in 2008 incorporates evidence that has become available since 2007. These guiddines focus on can: provided within hours to days of injury, chiefly within the combat zone, ll' those combat-injured patients with open wounds or bums. New in this UJXhle arc a consolidation of antimicrobial agent recommendations to a lmckhone of high-dose celivx,Jin with or without meh?onidamle fr;r most postinjury indications and recomfl1Cndations fhr redtlsing of antimicmbial agents, l(lf lL"<! of negative pressure wotu1d llll!rapy, and fix oxyg..:n supplt:mentation in !light

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care have allowed injured personnel to survive what previously would have been fatal injuries. Personnel surviving these severe injuries, which are often complex and associated with extensive tissue destruction, are at high risk for both early and remote infectious complications. Strategies to prevent these infections are chiefly derived from retrospective review of experiences in past and current conflicts, from civilian trauma data, and from in vitro and animal data. The best clinical practices to prevent infections in combat injuries have not been fully established. The following guidelines integrate available evidence and expert opinion, from the military and civilian medical community, both within and outside of the United States. These updated guidelines provide recommendations to healthcare providers for the management of combat-injured patients with open wounds or burns to prevent infectious complications. They focus on care from point of injury until arrival to tertiary care facilities outside of the combat zone. Postinjury antimicrobials, early wound cleansing (irrigation) and surgical debridement, delayed closure, and bony stabilization, with emphasis on maintenance of infection control measures,[1] are the essential components in reducing the incidence of these infections. New in this update are a consolidation of antimicrobial agent recommendations to a backbone of high-dose cefazolin with or without metronidazole for most postinjury indications and recommendations for redosing of antimicrobial agents, for use of negative pressure wound therapy (NPWT), and for oxygen supplementation in flight. Although focused on prevention of infections after injuries produced by combat, these guidelines may be applicable to noncombat traumatic injuries under certain circumstances.

Each section begins with a question and is followed by numbered recommendations from the panel with strength and quality of supporting evidence ratings (Table 1). In addition, a table is included to guide use of these recommendations based on the (US military) level of medical care (Table 2). Recommendations are supported by the five evidence-based reviews included in this *Journal of Trauma* supplement: (1) *Prevention of Infections Associated With Combat-Related Extremity Injuries,*[2] (2) *Prevention of Infections Associated With Combat-Related Central Nervous System Injuries,*[3] (3) *Prevention of Infections Associated With Combat-Related Eye, Maxillofacial, and Neck Injuries,*[4] (4) *Prevention of Infections Associated With Combat-Related Thoracic and*

TABLE 1. GRADE* Systematic Weighting of the Quality of Evidence and Grading of Recommendations

Strength of Recommendation and Quality of Evidence	Methodological Quality of Supporting Evidence (Examples)	Clarity of Balance Between Desirable and Undesirable Effects
IA Strong recommendation, high-quality evidence	Consistent evidence from well-performed RCTs or exceptionally strong evidence from unbiased observational studies	Desirable effects clearly outweigh undesirable effects or vice versa
IB Strong recommendation, moderate-quality evidence	Evidence from RCTs with important limitations (inconsistent results, methodological flaws, indirect, or imprecise) or exceptionally strong evidence from unbiased observational studies	Desirable effects clearly outweigh undesirable effects or vice versa
IC Strong recommendation, low-quality evidence	Evidence for at least one critical outcome from observational studies, RCTs with serious flaws or indirect evidence	Desirable effects clearly outweigh undesirable effects or vice versa
ID Strong recommendation, very low-quality evidence	Evidence for at least one critical outcome from unsystematic clinical observations or very indirect evidence	Desirable effects clearly outweigh undesirable effects or vice versa
IIA Weak recommendation, high-quality evidence	Consistent evidence from well-performed RCTs or exceptionally strong evidence from unbiased observational studies	Desirable effects closely balanced with undesirable effects
IIB Weak recommendation, moderate-quality evidence	Evidence from RCTs with important limitations (inconsistent results, methodological flaws, indirect, or imprecise) or exceptionally strong evidence from unbiased observational studies	Desirable effects closely balanced with undesirable effects
IIC Weak recommendation, low-quality evidence	Evidence for at least one critical outcome from observational studies, from RCTs with serious flaws or indirect evidence	Uncertainty in the estimates of desirable effects, harms, and burden; desirable effects, harms, and burden may be closely balanced
IID Weak recommendation, very low-quality evidence	Evidence for at least one critical outcome from unsystematic clinical observations or very indirect evidence	Major uncertainty in the estimates of desirable effects, harms, and burden; Desirable effects may or may not be balanced with undesirable effects may be closely balanced

RCTs, randomized controlled trials.
* Grades of Recommendation, Assessment, Development, and Evaluation (GRADE), www.gradeworkinggroup.org.

TABLE 2. Recommendations to Prevent Infections Associated With Combat-Related Injuries Based on Level of Care

Level of Care*	Care Category	Recommendations
Role 1/Level I (prehospital)	Initial care in the field	Bandage wounds with sterile dressings (avoid pressure over eye wounds) (**IB**)
		Stabilize fractures (**IB**)
		Transfer to surgical support as soon as feasible (**IB**)
	Postinjury antimicrobials	Provide single-dose point-of-injury antimicrobials (Table 3) if evacuation is delayed or expected to be delayed (**IC**)
Role 1/Level I/ Role 2/Level II without surgical support (IIa)	Postinjury antimicrobials	Provide IV antimicrobials (Table 3) as soon as possible (within 3 h) (**IB**)
		Provide tetanus toxoid and immune globulin as appropriate
		Enhance gram-negative coverage with aminoglycoside or fluoroquinolone not recommended (**IB**)
		Addition of penicillin to prevent clostridial gangrene or streptococcal infection is not recommended (**IC**)
		Redose antimicrobials if large volume blood produce resuscitation (**IC**)
		Use only topical antimicrobials for burns (**IB**)
	Debridement and irrigation	Irrigate wounds to remove gross contamination with normal saline, sterile, or potable water, under low pressure (bulb syringe or equivalent) without additives (**IB**)
		Do not attempt to remove retained deep soft tissue fragments if criteria met (**IB**).† Provide cefazolin 2 g IV × 1 dose
Role 2/Level II with surgical support (IIb)/ Role 3/ Level III	Postinjury antimicrobials	Provide IV antimicrobials (Table 3) as soon as possible (within 3 h) (**IB**)
		Provide tetanus toxoid and immune globulin as appropriate
		Enhance gram-negative coverage with aminoglycoside or fluoroquinolone not recommended (**IB**)
		Addition of penicillin to prevent clostridial gangrene or streptococcal infection is not recommended (**IC**)
		Redose antimicrobials if large volume blood produce resuscitation (**IC**)
		Use only topical antimicrobials for burns (**IB**)
		Antimicrobial beads or pouches may be used (**IB**)
		Provide postsplenectomy immunizations if indicated (**IB**)
	Debridement and irrigation	Irrigate wounds to remove contamination with normal saline or sterile water, under low pressure (5–10 PSI, e.g., bulb syringe or gravity flow) without additives (use 3 L for each Type I, 6 L for each Type II, and 9 L for each Type III extremity fractures) (**IB**)
		Do not attempt to remove retained deep soft tissue fragments if criteria met (**IB**).† Provide cefazolin 2 g IV × 1 dose
		Do not obtain cultures unless infection is suspected (**IB**)
	Surgical wound management	Surgical evaluation as soon as possible (**IB**)
		Only dural and facial wounds should undergo primary closure (**IB**)
		NPWT can be used (**IB**)
		External fixation (temporary spanning) of femur/tibia fractures (**IB**)
		External fixation (temporary spanning) or splint immobilization of open humerus/forearm fractures (**IB**)
Role 4/Level IV	Postinjury antimicrobials	Complete course of postinjury antimicrobials (Table 3)
		Antimicrobial beads or pouches may be used (**IB**)
		Provide postsplenectomy immunizations if indicated (**IB**)
	Debridement and irrigation	Irrigate wounds to remove contamination with normal saline or sterile water, under low pressure (5–10 PSI, e.g., bulb syringe or gravity flow) without additives (use 3 L for each Type I, 6 L for each Type II, and 9 L for each Type III extremity fractures) (**IB**)
		Do not attempt to remove retained deep soft tissue fragments if criteria met (**IB**).† Provide cefazolin 2 g IV × 1 dose
		Do not obtain cultures unless infection is suspected (**IB**)
	Surgical wound management	Wounds should not be closed until 3–5 d postinjury (**IB**)
		Only dural and facial wounds should undergo primary closure (**IB**)
		NPWT can be used (**IB**)
		External fixation (temporary spanning) of femur/tibia fractures (**IB**)
		External fixation (temporary spanning) or splint immobilization of open humerus/forearm fractures (**IB**)

IV, intravenous; PSI, pounds per square inch.

* Role of care, level of care, and echelon of care are considered synonymous with role currently the preferred US military term. Definitions of role/level/echelon of care: *Role 1*—self-aid, buddy aid, combat lifesaver, and combat medic/corpsman care at the point-of-injury; physician/physician assistant care at battalion aid station (BAS; US Army) or shock trauma platoon (US Marine Corps [USMC]); no patient holding capacity; *Role 2*—medical company (includes forward support medical company, main support medical company, and area support medical company in US Army) or expeditionary medical support (EMEDS, US Air Force [USAF]); 72 h patient holding capacity, basic blood transfusion, radiography, and laboratory support. May be supplemented with surgical assets (2b) (forward surgical team, US Army; mobile field surgical team, USAF; forward resuscitative surgical system, USMC); *Role 3*—combat support hospital (CSH, US Army), Air Force theater hospital (AFTH, USAF), or casualty receiving ships (USN); full inpatient capacity with intensive care units and operating rooms; *Role 4*—regional hospital (Landstuhl Regional Medical Center, Germany) or USNS hospital ships (USN), typically outside of the combat zone; general and specialized inpatient medical and surgical care; *Role 5*—care facilities within United States, typically tertiary care medical centers.

† Criteria for allowing retained fragments to remain behind: entry/exit wounds <2 cm; no bone, joint, vascular, and body cavity involvement; no high-risk etiology (e.g., mine); no obvious infection; and assessable by X-ray.

Abdominal Cavity Injuries,[5] *and* (5) *Prevention of Infections Associated With Combat-Related Burn Injuries.*[6]

RECOMMENDATIONS FOR THE PREVENTION OF INFECTIONS ASSOCIATED WITH COMBAT-RELATED INJURIES

A. Initial Care in the Field

I. What Initial Care/Stabilization Should be Provided to the Injured Patient in the Field Before Evacuation to a Medical Care Facility (Medical Treatment Facilities)?

1. Wounds should be bandaged with sterile dressing and fractures stabilized before transportation to higher level of care (**IB**) (Table 2).
2. Dressing covering the eye should provide protection while avoiding producing pressure on the orbit (**IB**). A Fox shield or other such device should be employed.
3. Patients should be transferred to a facility with surgical support as soon as feasible (**IB**) (see recommendation 44).
4. Given the unpredictable nature of casualty evacuation in a combat zone, point-of-injury antimicrobial agents (see recommendation 20) should be provided if evacuation is delayed or expected to be delayed (**IC**).

B. Postinjury Antimicrobials

II. Should Systemic Antimicrobials be Given to Patients With Combat-Related Injuries Immediately Postinjury?

5. Systemic antimicrobials should be administered as soon as possible after injury to prevent early infectious complications, including sepsis, caused by common bacterial flora. Ideally, postinjury antimicrobials should be given within 3 hours of injury (**IB**).

III. Which Antimicrobials (and What Dosing Regimens) Should be Employed for Postinjury Use?

6. Antimicrobial selection should focus on providing the narrowest spectrum of activity required, providing coverage of expected common bacterial flora. If multiple injuries are present, the antimicrobial agent selection should be based on the narrowest spectrum needed to cover all wound sites/types (**IB**). Postinjury antimicrobials are provided to prevent early infectious complications, including sepsis. These recommended antimicrobials are not meant to treat established infections where nosocomial pathogens, including multidrug-resistant, may be the infecting agents (Table 3).
7. Selected agents should be dosed to maximize pharmacokinetics and pharmacodynamics. Logistical considerations, including limiting number of agents to be stocked and maintaining sufficient quantities in the combat zone, should also be considered.

Extremity Wounds

8. Cefazolin, 2 g intravenously (IV) every 6 hours to 8 hours, should be used as the antimicrobial of choice in extremity injuries (skin, soft tissue, and/or bone) (**IB**). Clindamycin may be given as an alternate agent if previous documented anaphylaxis to β-lactam antimicrobials.
9. Enhanced gram-negative coverage should not be employed (**IB**).
10. Addition of penicillin to provide antimicrobial coverage of clostridial gangrene and group A β-hemolytic *Streptococcus* infections is not required (**IC**).

Central Nervous System Wounds

11. Cefazolin, 2 g IV every 6 hours to 8 hours, should be employed for central nervous system (CNS) injuries (**IB**).
12. Add metronidazole, 500 mg IV every 8 hours to 12 hours, if brain grossly contaminated with organic debris (**ID**).
13. Add metronidazole, 500 mg IV every 8 hours to 12 hours, if spinal cord injury associated with concomitant abdominal cavity penetration (**IC**).

Eye, Maxillofacial, and Neck Wounds

14. For penetrating eye injuries, levofloxacin, 500 mg IV or orally every 24 hours, should be provided (**IB**).
15. For maxillofacial and neck injuries, cefazolin, 2 g IV every 6 hours to 8 hours, should be provided (**IC**). Clindamycin, 600 mg IV every 8 hours, may be used as an alternate (**IC**).

Thoracic and Abdominal Cavity Wounds

16. For thoracic cavity injuries without disruption of the esophagus, cefazolin, 2 g IV every 6 hours to 8 hours, should be used (**IIB**).
17. Cefazolin, 2 g IV every 6 hours to 8 hours, with metronidazole, 500 mg IV every 8 hours to 12 hours, should be provided for penetrating wounds to the abdomen and penetrating wounds to the thorax that result in esophageal injury (**IIB**). Alternate regimens include single-dose ertapenem (1 g IV) or moxifloxacin (400 mg IV) (**IIB**).

Burns

18. Topical antimicrobial agents should be used for burn wounds in conjunction with debridement (**IB**). Silver sulfadiazine cream alternating with mafenide acetate cream is preferred. Debridement may not be feasible at lower levels of care; in this situation, clean, dry dressing should be applied to burn wound until the patient is transferred to a higher level of care.
19. Systemic antimicrobials are not indicated for postinjury therapy (**IC**), or for debridement performed as part of routine wound care (**IB**), unless required for concomitant traumatic injuries. Systemic antimicrobials may be considered for perioperative prophylaxis during excision and grafting procedures (**IC**). Cefazolin, 2 g IV every 6 hours to 8 hours for 24 hours, is sufficient for coverage of skin flora. However, antimicrobial agents effective against *Pseudomonas* should be considered if wounds are grossly colonized or older than 5 days.

TABLE 3. Postinjury Antimicrobial Agent Selection and Duration Based Upon Injury Pattern*

Injury	Preferred Agent(s)	Alternate Agent(s)	Duration
Extremity wounds (includes skin, soft tissue, and bone)			
Skin, soft tissue, no open fractures	Cefazolin 2 g IV q 6–8 h†‡	Clindamycin (300–450 mg PO TID or 600 mg IV q 8 h)	1–3 d
Skin, soft tissue, with open fractures, exposed bone, or open joints	Cefazolin 2 g IV q 6–8 h†‡§	Clindamycin 600 mg IV q 8 h	1–3 d
Thoracic wounds			
Penetrating chest injury without esophageal disruption	Cefazolin 2 g IV q 6–8 h†‡	Clindamycin (300–450 mg PO TID or 600 mg IV q 8 h)	1 d
Penetrating chest injury with esophageal disruption	Cefazolin 2 g IV q 6–8 h†‡ plus metronidazole 500 mg IV q 8–12 h	Ertapenem 1 g IV × 1 dose or moxifloxacin 400 mg IV × 1 dose	1 d after definitive washout
Abdominal wounds			
Penetrating abdominal injury with suspected/known hollow viscus injury and soilage; may apply to rectal/perineal injuries as well	Cefazolin 2 g IV q 6–8 h†‡ plus metronidazole 500 mg IV q 8–12 h	Ertapenem 1 g IV × 1 dose or moxifloxacin 400 mg IV × 1 dose	1 d after definitive washout
Maxillofacial and neck wounds			
Open maxillofacial fractures, or maxillofacial fractures with foreign body or fixation device	Cefazolin 2 g IV q 6–8 h†‡	Clindamycin 600 mg IV q 8 h	1 d
Central nervous system wounds			
Penetrating brain injury	Cefazolin 2 g IV q 6–8 h.†‡ Consider adding metronidazole 500 mg IV q 8–12 h if gross contamination with organic debris	Ceftriaxone 2 g IV q 24 h. Consider adding metronidazole 500 mg IV q 8–12 h if gross contamination with organic debris. For penicillin allergic patients, vancomycin 1 g IV q 12 h plus ciprofloxacin 400 mg IV q 8–12 h	5 d or until CSF leak is closed, whichever is longer
Penetrating spinal cord injury	Cefazolin 2 g IV q 6–8 h.†‡ ADD metronidazole 500 mg IV q 8–12 h if abdominal cavity is involved	As above. ADD metronidazole 500 mg IV q 8–12 h if abdominal cavity is involved	5 d or until CSF leak is closed, whichever is longer
Eye wounds			
Eye injury, burn or abrasion	Topical: Erythromycin or Bacitracin ophthalmic ointment QID and PRN for symptomatic relief Systemic: No systemic treatment required	Fluoroquinolone 1 drop QID	Until epithelium healed (no fluorescein staining)
Eye injury, penetrating	Levofloxacin 500 mg IV/PO once daily. Before primary repair, no topical agents should be used unless directed by ophthalmology		7 d or until evaluated by a retinal specialist
Burns			
Superficial burns	Topical antimicrobials with twice daily dressing changes (include mafenide acetate‖ or silver sulfadiazine; may alternate between the two), silver-impregnated dressing changed q 3–5d, or Biobrane	Silver nitrate solution applied to dressings	Until healed
Deep partial-thickness burns	Topical antimicrobials with twice daily dressing changes, or silver-impregnated dressing changed q 3–5 d, plus excision and grafting	Silver nitrate solution applied to dressings plus excision and grafting	Until healed or grafted
Full-thickness burns	Topical antimicrobials with twice daily dressing changes plus excision and grafting	Silver nitrate solution applied to dressings plus excision and grafting	Until healed or grafted

TABLE 3. Postinjury Antimicrobial Agent Selection and Duration Based Upon Injury Pattern* (continued)

Injury	Preferred Agent(s)	Alternate Agent(s)	Duration
Point-of-injury/delayed evacuation¶			
Expected delay to reach surgical care	Moxifloxacin 400 mg PO × 1 dose. Ertapenem 1 g IV or IM if penetrating abdominal injury, shock, or unable to tolerate PO medications	Levofloxacin 500 mg PO × 1 dose. Cefotetan 2 g IV or IM q 12 h if penetrating abdominal injury, shock, or unable to tolerate PO medications	Single-dose therapy

IV, intravenous; PO, orally; IM, intramuscularly; TID, three times daily; QID, four times daily; PRN, as needed; CSF, cerebrospinal fluid.

* Postinjury antimicrobial agents are recommended to prevent early posttraumatic infectious complications, including sepsis, secondary to common bacterial flora. Selection is based on narrowest spectrum and duration required to prevent early infections before adequate surgical wound management. This narrow spectrum is selected to avoid selection of resistant bacteria. The antimicrobials listed are not intended for use in established infections, where multidrug-resistant or other nosocomial pathogens may be causing infection.

† Cefazolin may be dosed based on body mass: 1 g if weight ≤80 kg (176 lbs), 2 g if weight 81–160 kg (177–352 lbs), 3 g if weight >160 kg (>352 lbs); doses up to 12 g daily are supported by FDA-approved package insert.

‡ Pediatric dosing: cefazolin, 20–30 mg/kg IV q 6–8 h (maximum, 100 mg/kg/d); metronidazole, 7.5 mg/kg IV q 6 h; clindamycin 25–40 mg/kg/d IV divided q 6–8 h; ertapenem, 15 mg/kg IV or IM q 12 h (children up to 12 yr) or 20 mg/kg IV or IM once daily (children over 12 yr; maximum, 1 g/d); ceftriaxone, 100 mg/kg/d IV divided q 12–24 h (dosing for CNS injury); levofloxacin, 8 mg/kg IV or PO q 12 h (levofloxacin is only FDA-approved in children for prophylaxis of inhalational anthrax in children older than 6 mo, but this dose is commonly used for other indications); vancomycin, 60 mg/kg/d IV divided q 6 h (dosing for CNS injury); ciprofloxacin, 10 mg/kg IV (or 10–20 mg/kg PO) q 12 h.

§ These guidelines do not advocate adding enhanced gram-negative bacteria coverage (i.e., addition of fluoroquinolone or aminoglycoside antimicrobials) in Type III fractures.

‖ Mafenide acetate is contraindicated in infants younger than 2 mo.

¶ Postinjury antimicrobial therapy as suggested by the Tactical Combat Casualty Care Committee.

Point-of-Injury Antimicrobial Selection

20. Point-of-injury antimicrobials as suggested by the Tactical Combat Casualty Care Committee currently include moxifloxacin, 400 mg orally, if casualty does not have penetrating abdominal trauma, is not in shock, and can take oral medications. In patients who do not meet these criteria, single-dose ertapenem (1 g IV or intramuscularly [IM]) or cefotetan (2 g IV or IM) every 12 hours has been suggested. IV therapy is preferred over IM.

Pediatric Considerations

21. Children should be treated with the same antimicrobial agents as those suggested for adults, including those topical antimicrobials suggested for burns. Dosing of antimicrobials in children weighing less than 40 kg should be weight-based. Cefazolin should be dosed at 20 mg/kg to 30 mg/kg IV every 6 hours to 8 hours (up to maximum of 100 mg/kg/d). Metronidazole should be dosed at 30 mg/kg/d IV in four divided doses.

IV. What Duration of Antimicrobials Should be Given to Patients After Combat-Related Injuries?

22. The shortest course of postinjury antimicrobial therapy should be used (**IB**) (Table 3). If multiple wounds are present, the duration of antimicrobials is dictated by the injury pattern requiring the longest duration of therapy. Duration should not be extended for open wounds, drains, or external fixation devices. Wounds should be continually reassessed for evidence of infection and antimicrobials directed specifically at known or empirically suspected infecting pathogens provided if infection is suspected or proven.

Extremity Wounds

23. Antimicrobials should be provided for 1 day to 3 days for all extremity wounds (**IB**).

CNS Wounds

24. Antimicrobials are recommended for 5 days or until cerebrospinal fluid leak is closed, whichever time period is longer (**ID**).

Eye, Maxillofacial, and Neck Wounds

25. For penetrating eye injuries, antimicrobials should be provided for a total of 7 days or until a thorough evaluation by a retinal specialist with adequate capabilities has been performed (**IC**).
26. For maxillofacial and neck injuries, 1 day of antimicrobial coverage should be provided (**IC**).

Thoracic and Abdominal Cavity Wounds

27. Thoracic injuries with esophageal injury should also receive a total of 1 day of antimicrobials after definitive operative washout (**IB**).
28. Casualties should receive a total of 1 day of antimicrobials after definitive operative washout for abdominal cavity injuries (**IB**).

Burns

29. Topical antimicrobial agents should be used for burns until wounds are successfully covered with healed skin, whether spontaneously or following successful skin grafting (**IC**).

V. Should Antimicrobials be Redosed Before Next Schedule Dosing Interval if Patients Require Substantial Blood Product Support, Require Large Volume Resuscitation, or Have Severe Acidosis?

30. Redosing of antimicrobials should be performed after large volume blood product resuscitation (1,500–2,000 mL of blood loss) has been completed, regardless of when the last dose of antimicrobial was administered (**IC**).

VI. Should Local Delivery of Antimicrobials Through Topical Application or Beads (Bead Pouches) be Implemented in the Care of Combat-Related Injuries?

31. Local delivery of topical antimicrobials may be provided for extremity infections in the form of antimicrobial beads or pouches as long as the emphasis is still on surgical debridement and irrigation (**IB**).
32. Local delivery of other antimicrobials (other than in burn care), to include powders or soaking of wet to dry dressing with antimicrobials, should not be used routinely (**IB**).

VII. What Vaccines or Other Immunotherapy Should be Provided Postinjury?

Tetanus Toxoid or Immune Globulin

33. Patients who have been previously immunized against tetanus (received 3 or more doses of toxoid) do not require booster dose of vaccine unless it has been more than 5 years since their last dose. They do not require tetanus immune globulin (TIG) (**IB**).
34. Unimmunized patients, and those with unknown vaccination status, should receive TIG and vaccine (with additional doses of vaccine given at 4 weeks and 6 months) postinjury (**IC**).
35. Early surgical debridement and irrigation in addition to postinjury antimicrobials and vaccine may be effective in the prevention of tetanus in the absence of TIG administration (**IID**).

Postsplenectomy Immunization

36. Patients who have had their spleens removed should receive immunization against *Streptococcus pneumoniae*, *Neisseria meningitidis*, and *Hemophilus influenza* serotype B (**IB**). Immunization should be provided within 14 days of splenectomy.

C. Debridement and Irrigation

VIII. When Should Irrigation Fluid be Implemented in the Management of Combat-Related Injuries?

37. Wound irrigation should be initiated as soon as clinically possible by appropriately trained personnel (**ID**).

IX. Should Additives Supplement Irrigation Fluid for Combat-Related Injuries?

38. Additives should not be included in standard irrigation fluid as normal saline (or alternately, sterile water or potable water) is adequate (**IB**).

X. What Volume of Fluid Should be Used to Irrigate Wounds Associated With Combat Injuries?

39. Sufficient volume to remove debris should be employed (**IB**). For extremity injuries, standard volumes of 3 L, 6 L, and 9 L should be provided for Type I, II, and III fractures, respectively; however, larger volumes might be required for more severe injuries (**IB**).

XI. What Pressure Should be Used to Deliver Irrigation in the Management of Combat-Related Injuries?

40. Irrigation fluid should be delivered at low pressure (5–10 PSI may be delivered by bulb syringe or gravity irrigation) (**IB**).

XII. Should Pre- and/or Postdebridement Bacterial Culture of Combat-Related Wounds be Performed?

41. Clinicians should obtain bacterial cultures only when there are concerns for an ongoing wound infection based upon systemic signs or symptoms of infection, local appearance of wounds, and laboratory or radiographic imaging studies (**IB**).
42. Results from infection control surveillance cultures should not be used for initiation of therapy (**IC**).

XIII. Can Retained Soft Tissue Fragments Remain in a Combat-Related Injury Wound?

43. Casualties with isolated retained deep extremity soft tissue metal fragments meeting certain clinical and radiographic criteria should be treated with a single dose of cefazolin, 2 g IV, without fragment removal (**IB**). Patients should be monitored for evidence of subsequent infection.

D. Surgical Wound Management

XIV. When Should Patients With Combat-Related Injuries Undergo Initial Surgical Management?

44. Patients should be evacuated to surgical care as soon as possible based upon a risk-benefit analysis of the combat environment (**IB**).

45. Penetrating injuries of the eye (**IB**) and spine without neurologic compromise (**IC**) should await surgical debridement until appropriate surgical expertise is available.
46. Foreign material embedded in the brain, which are not readily accessible, should not be removed by non-neurosurgeons (**IB**).
47. All burn injuries should undergo thorough cleansing and debridement, estimation of extent and depth, and coverage with appropriate topical antimicrobial agents within 8 hours of injury (**IC**). Early (within 5 days) excision and grafting is suggested for deep partial-thickness and full-thickness burns (**IA**). This should ideally be performed outside of the combat zone by surgeons with appropriate training and experience.

XV. When Should Combat-Related Wounds be Closed?

48. Wounds, to include open fractures, should not be closed early; typical closure should be performed 3 days to 5 days after injury if there is no evidence of infection (**IB**).
49. For injuries that involve the face or dura, primary closure should be performed (**IB**).
50. For abdominal and thoracic injuries, the skin should not be closed if there is a colon injury or extensive devitalized tissue due to excessive infectious complications (**IB**).
51. Early primary repair of complex or destructive colonic injuries should not be performed especially if associated with massive blood transfusion, ongoing hypotension, hypoxia, reperfusion injury, multiple other injuries, high velocity injury, or extensive local tissue damage (**IB**).
52. If the abdomen is left open, the possibility of partial or complete closure should be considered at each subsequent laparotomy (**IB**).
53. Scheduled laparotomies should be performed in this group at 24-hour to 48-hour intervals (**IB**).

XVI. Should External Fixation be Standard for Stabilization of Fracture?

54. Temporary spanning external fixation should be placed for femoral and tibial fractures (**IB**). Use of external fixation in the current conflicts allows stabilization during long evacuations to the United States, easy observation of wounds (over use of plaster), and potentially less chronic infections (over early open reduction and internal fixation).
55. Temporary spanning external fixation or splint immobilization placement with transition to open plate and screw osteosynthesis should be employed for open humerus and forearm fractures after soft tissue stabilization (**IB**).

XVII. Can NPWT be Used in the Management of Combat-Related Wounds?

56. NPWT should be used in the management of open wounds (excluding CNS injuries) to include during aeromedical evacuation of patients (**IB**).
57. Use of intermittent suction or instillation of normal saline in conjunction with NPWT is discouraged in most situations based upon preliminary animal studies (**ID**).
58. Local delivery of antimicrobials using beads or pouches might be effective in combination with NPWT and could be considered (**IID**).

XVIII. Should Supplemental Oxygen be Provided During Transportation of the Wounded to Medical Facilities Outside the Combat Zone?

59. During aeromedical evacuation, supplemental oxygen (to maintain oxygen saturation >92%) may be beneficial in patients with combat-related injuries (**IIC**).

E. Facility Infection Control and Prevention

XIX. What Infection Control and Prevention Measures Should be Implemented in Deployed Medical Treatment Facilities?

60. Basic infection control and prevention measures should be employed at all deployed medical treatment facilities (MTF). These should include hand hygiene, with compliance monitoring. Infection control and prevention should include MTF Commander oversight and emphasis (**IB**).
61. Transmission-based (isolation) precautions should be implemented (**IB**).
62. Cohorting (i.e., physically separating patients expected to be hospitalized for less than 72 hours from those expected to be hospitalized longer) should be used (**IC**).
63. An infection control officer should be assigned to each deployed MTF that provides inpatient care. This officer should have adequate training and experience to lead the infection control program at the MTF.
64. All deployed MTF should practice antimicrobial stewardship (**IC**). Clinical microbiology assets are crucial to antimicrobial stewardship and should be available at MTF which hospitalize patients for more than 72 hours.

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